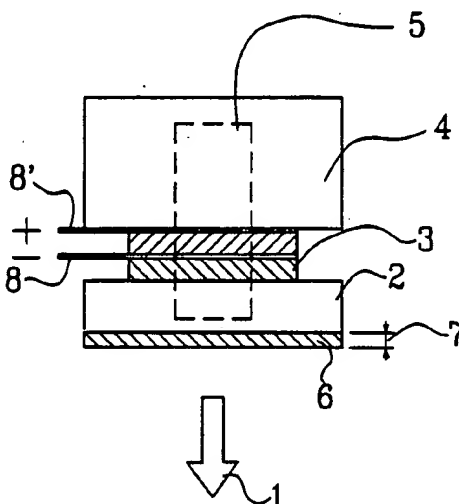




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/DK93/00263 <b>(22) International Filing Date:</b> 13 August 1993 (13.08.93) <b>(30) Priority data:</b> 1025/92 18 August 1992 (18.08.92) DK <b>(71) Applicant (for all designated States except US):</b> RESEN SYSTEM A/S [DK/DK]; Fabriksvangen 13, DK-3550 Slangerup (DK). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only) :</b> RESEN STEENSTRUP, Claus [DK/DK]; Strandøre 9, DK-2100 København Ø (DK). RESEN STEENSTRUP, Per [DK/DK]; Christiansholmsvej 12, DK-2930 Klampenborg (DK). RESEN STEENSTRUP, Jens [DK/US]; San Gabriel LN 3614, Santa Barbara, CA 93105 (US). LYNDELSEN, Michael, Christian [DK/DK]; Ryesgade 107, 3 mf, DK-2100 København Ø (DK). HARALDSTED, Hans, H. [DK/DK]; Ellegaardspark 19, Postbox 107, DK-3520 Farum (DK).		<b>(74) Agent:</b> HANS H. HARALDSTED; Ingeniør- & Handelsfirma ApS, Ellegaardspark 19, Postbox 107, DK-3520 Farum (DK). <b>(81) Designated States:</b> AT, AU, BB, BG, BR, BY, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). <b>Published</b> <i>With international search report.</i> <i>In English translation (filed in Danish).</i>

**(54) Title:** TRANSDUCER WITH HIGH EFFECTIVE MEMBRANE OF CAVITATION



**(57) Abstract**

High effective ultra sound transducer (2, 3 and 4) for especially the transmitter frequencies (4) from 20-100 KHz used especially in connection with operations of homogenizing as operations of cleaning, where the metal front and the head of the transmitter flat (2) is covered (6) with a membrane of cavitation (6), which is acoustics transparent and which is elastic. The transducer (2, 3 and 4) can further be mounted as a single row of transducers in a common battery (2', 3' and 4') and in a watertight box (9), where the single transducers (2, 3 and 4) here can be fluent and elastic hang (10) and fixed (10) via a common membrane of cavitation (6'), which again can be fixed or ideal be vulcanized to the edge of the battery front (9) as the head as a steady plate of supporting and transmitting (9').

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TRANSDUCER WITH HIGH EFFECTIVE MEMBRANE OF CAVITATION.

The invention relate to a high effective ultra sound  
5 transducer for transmitting frequencies from 20-100 KHz,  
used especially in connection with operations of homo-  
genizing as cleaning operations.

Hitherto is known ultra sound transducers used before  
10 abovementioned area, where one have made the transmitting  
head and especially the aera of the transmitter front in  
metal as an example aluminium as stainless steel.

The disadvantage has in connection with formed cavitation  
in the surrounding liquid at and from the area of the  
15 transmitter front done, that the always formed air  
bubbles of cavitation with often an air pressure up to  
1000 bars or more, have corroded and eat away into the  
surface of the metal transduce, when the bubbles of  
cavitation have been collapsed. The equipment has  
20 therefore only got a relative short time of life.

Hitherto one have also got big problems with a direct  
mounting in especially the metal transducer houses, where  
the vibrations of the transduce often have done, that the  
25 watertight transducer units have been self destroying,  
why they very fast have been leaky, and there have after  
this been pressed liquid in to the belonging electronic.

Hitherto one have not known transducers, where they  
30 integrated in each other have been able to force the  
effect of each other or to make a "effect of synerg1", so  
that there has been made an untill now unknown optimal  
effect in the procedure of cleaning as the procedure of  
homogenization.

35

The purpose with the invention is to eliminate hitherto

known problems especially the corrosions there have been made in connection with cavitation, when an equipment of abovementioned sort has been used.

The purpose with the invention is further to eliminate  
5 till then now known problems, especially destroying vibrations on the materials and theirs connection, there have been arisen on the equipment itself, when this has been used.

10 The purpose is also in an alternative embodiment, to make use of the new vibration free attachment to one in its own integrated multy transducer, there especially in effect will be self strengthen and be able to obtain results, there are better than untill now known for a  
15 simple equipment.

This has been obtained according to the invention by a transducer of this in the beginning mentioned sort and characteristic of, that the metal front and the head of  
20 the transmitter are covered with a cavitations membrane, which is acoustics transparent and which is elastic.

The manner of working of the membrane of cavitation will especially shown, that the elastic membrane counteract  
25 the constantly action of the pressure of explosion of the bubbles of the cavitations against the vibrating front flat on the transducer, as the material of the membrane is so elastic, but still relatively hard, that the energy from the bubbles of cavitation total will be leaved and  
30 quelled in the material. And because the transducer is dipped in the liquid, so will this made a cooling effect on the material of membrane.

The elastic material of membrane will more over also done or made an extra springy push on the sound waves and of  
35 this movement in the liquid in front of the transducer, as the transducer got an extra powerfull energy of

pushing via the elastic, but still acoustics transparant membrane of cavitation.

The system in working function can roughly be compared  
5 with the modern technology swiping rod used at the fishing, where a retarded swip of the swiping rod because of the stored energy do that the line with the fish-hook is flying longer.

The membran of cavitation through the air-bubbles of  
10 energy longer and more powerfull out or away.

In a specially embodiment for the membran of cavitation according to the invention, then can the ultra sound transducer be mounted as a row of single transducers into  
15 a joint battery, and in a watertight box, where the single transducer is flowing and elastic hung and fixed via a common membrane of cavitation front, which again can be fixed or ideal vulcanized to the edge of the front of the battery as firm supporting and front flat.

20

I another embodiment for membran of cavitation according to the invention, then can the single ultra sound transducer in battery as single arrangment be fluent hung and tightend via a movable arrangment of O-ring in the  
25 front of the transmitter head and with a relative possibility of stroke in the direction of the cylinder head.

In another embodiment for the membran of cavitation  
30 according to the invention, then can the single transducer head, there especially is fluent hung, but also without a total arrangment of the membran of cavitation be made with one in it own supplying integrated arrangment of transducer, there in this is fluent hung, and  
35 with its prospective seperate and independent system of membran of cavitation, but even also without this.

Favourable modify embodiments of the invention will after this appear from the sub-claims.

The invention shall be explained neare in the following  
5 under reference to the drawings of the figure, where

Fig.1 shows a high-effective ultra sound transducer  
in section,  
10

Fig.2 shows a battery of ultra sound transducers in  
section,

Fig.3 shows a single transducer in a box, with  
15 membrane of cavitation,

Fig.4 shows a transducer in a box, hung fluent via  
a system of O-ring,

20 Fig.5 shows a transducer with exchangeable front  
part,

Fig.6 shows an alternative fluent hanging com-  
binated with an exchangeable membrane of the front part,  
25

Fig.7 shows an integrated double transducer,

Fig.8 shows a head transducer with an integrated  
system of transducers.  
30

Fig.1 shows a high effective ultra sound transducer  
2,3 and 4 in section, where the front of the sound 2 or  
the head plate 2 is covered 6 on the transmitter side 2  
with an elastic membrane of cavitation 6.  
35 The ultra sound transducer 2,3 and 4 form an ultra- sound  
1 via two fixed piezo-crystals 3, where there between the

- parts are laid an electrical conducting foil 8 and 8', where there are transmitted a voltage. The foil 8 and 8' and the front 2 as the back 4, which here is a block 4 with high density, has been glued together as an example a glue of epoxy. The system 2,3 and 4 has been pressed and fixed further as an example via a stem bolt 5, which squeeze the front and the transmitter head 2 as the mass back head tight, especially airtight together.
- The front-and the transmitter head 2 can be made of a metal with low density as an example aluminium, where opposite the back 4 or the block 4 of the sound counter end can be made in a material with high density as an example brass.
- 15 The advantage of this construction 2,3 and 4 is, that the sound energy 1 has been transmitted forward 1', with the transmitter front 2, where the material of the head 2 has a small density. Opposite the back 4, which almost not has been brought to oscillation according the law of
- 20 physics about mass multiply by acceleration, where the power of the oscillation from the oscillated crystals of piezo 3 generally has been turned forward 1, and has been effectuated in the transmitter head 2.
- 25 The thickness 7 of the membran of the cavitation 6, which especially ideal can be vulcanized to the transmitter head 2, can ideal be fitted for transmission according to the thickness 7, dependent of the property of the transmission of the elastic material 6, as the frequency
- 30 of the transmitter 1 of the transducer 2,3 and 4, and of this the velocity of the sound in the material of the membrane 6. Ideal can the thickness 7 of the material of membrane 6 be  $3/4$  of the wave-length of the transmitting. But other ideal thickness 7' could also be thought,
- 35 dependent of the purpose of the user as the total construction of the transducer 2,3 and 4.

As the ultra sound transducer 2, 3 and 4 in this embodiment often has been used before the sector of food to cleaning purposes and like that, then ought the material of membrane 6 satisfy normes approved to this sector. The hardness of the elastic material 6 can as an example into specially cleaning purposes ideal been lain on about 70 shore. And the material of membrane 6 can ideal as an example be made of rubber of nitrit.

Fig.2 shows a battery of ultra sound transducers 2, 3, 4 and 9 in section, where the transducers 2', 3' and 4' here are equipped with a common membrane of cavitation 6 with a back supporting plate 9', and where the battery of transducers 2', 3' and 4' totally as the transducers 2, 3 and 4 separately are hung fluent 10 with a transferred edge of membrane of cavitation 10. To guide "in side position" the singel fluent 10 and hung and here fixed vulcanized heads of transducers 2, 3 and 4, then is the membrane of cavitation 6 for each single head of transducer 2, 3 and 4 equipped with a guiding band -or blonde 10' along the front edge on the transmitter head 2 and on each transducers 2, 3 and 4.

The advantage to the design of the battry embodiment 2', 3' and 4' and 9 is that the sound transmitter front will be very wide, and therefore better can satisfy the requirements, which especially have been demanded to the cleaning operations as operations of homogenizing.

But also before similar other using purposes could this just mentioned construction 2', 3' and 4' as 9 or a variety of this be ideal and optimum.

Fig.3 shows a single transducer 2, 3 and 4 in box 9 with membrane of cavitation 6. In proportion to earlier known, then will the front plate 2 or the area 2' not here be corroded of bubbles of cavitation, but the system 2, 3 and 4 as 6 will on the contrary both protect the



transmitter head 2 as highten and extra turn forward the energy 1 of the cleaning bubbles of cavitation, as the generally sound energy 1 in the liquid. And to purpose of homogenizing will there also be a better effect to note.

- 5 The membrane of cavitation 6 is here made like the membrane of cavitation 6 for the battery transducer 2', 3' and 4'.

The membrane of cavitation 6 could even also have other optimum designs 6 as 7' and varying thickness 7 as an  
10 example concave as convex, and fitted to the front of sound transmitter 1 or the picture 1' from the transmitter section 2. Alternative could the surface on the membrane of cavitation 2 be made with a spot pinches surface, for partly to be able to spread the sound-waves  
15 1 in different directions. The membrane of cavitation 2 could even too be made as sound speaker funnel, where the sound picture 1' inside the area would be highten if necessary via also fitting to the resonance as fitting to the material of the membrane and so on.

20

Fig.4 shows a transducer 2 , 3 and 4 in a box 9, hung fluent 10 as 11 via a system of O-rings 11, where membrane of the cavitation 6 cover the transmitter front 2' on the head of the transducer 2.

- 25 The O-ring 11 can be elastic fixed 11 to the box of the transducer 9 via as an example an O-ring turned groove 11' in the house 9 as a turned groove 2' in the transmitter head 2 on the transducer 2 , 3 and 4.

The O-ring 11 could moreover further be fixed in the  
30 grooves via a gluing in each groove, as an example via contact-glue or another glue there stand the high ultra sound. Alternative could the system of O-ring 11 be vulcanized to and into the sides of the house, after which the transmitter head 2 could be fitted around the  
35 fluent ring of cavitation 11.

Fig.5 shows a transducer 2, 3 and 4 with exchangeable 2' transmitter front 2, as the transmitter front 2 as an example as shown here can be screwed 14 for compact rest against the body on the transmitter head 2.

5 The fluent hang of cavitation 11 as 11' can be establish with an extra stable system of O-ring 11 as 11' made as mentioned under Fig.4.

The membrane of cavitation 6 on the transmitter front 2' can be vulcanized on the front area 2', as strengthen  
10 also up along the sides 6' and short around on the back 6".

Fig.6 shows an alternative fluent hang 10 as 12 combined with an exchangeable front membrane 6, as the  
15 fluent hang 10 can be fixed between the front plate of the membrane 2' and the body of the transmitter head 2. The plate of the membrane front 2' can be fixed to the transmitter head 2 as mentioned under Fig.5. For that matter has the exchangeable plate of the front membrane  
20 2' as 6 the advantage, that the membrane 6 in its thickness 7 as according to its property of the material can be fitted 7' to the actual situation of operation 1". As an example by working of specially articles of food as medical products.

25

Fig.7 shows an integrated 12' double transducer 2, 3 and 4 as 2', 3' and 4', as there here are placed a  
fluent 10 hang transducer 2', 3' and 4' in the middle of the head transducer 2, 3 and 4.

30 The secondary transducer 2', 3' and 4' have the advantages 1' of work, that it 2', 3' and 4' will swing according to the sound 1' and relative in stroke 1 with the head transducer 2, 3 and 4, by which a supplying ultra sound transmitting 1" from the secondary transducer  
35 2', 3' and 4' either in the same frequency 1 or in another to the purpose fitted frequency 1', will be highten.

According to the sound 1 then will the front of the sound 1, which the big primary transducer 2, 3 and 4 transmit 1, also be more optimum, as a differentiated sound column 1 as 1' will be more optimum, than a single equal column of sound 1.

The procedure of cleaning will work better, as th two column of sound 1 and 1' by their difference of sound in the limit zone, will work extra optimum. And a double transducer 2, 3 and 4 as 2', 3' and 4' used for as an example to homogenizing will work more active in and on the working liquid or medium.

Fig.8 shows a head transducer 2, 3 and 4 with an integrated system of transducers 13, where the secondary transducers 13 have been lain in ring in the transmitter front 2 of the head transducers 2, 3 and 4.

The secondary transducers 13 can here either work together with the same frequency, or they can transmit with mutual different frequencies. Alternative one could think a head transducer 2, 3 and 4 driving or working alone, after which the secondary transducers 13 could work.

C L A I M S .

1. Method for making of a double effect transducer of cavitation (2, 3, 4 and 6) for the transmitting frequencies from 20- 100 KHZ, and used especially in connection with operations of homogenizing as operations of cleaning, characteristic of, that the transmitter front of the transducer (2) ideal can exist of according of the weight to a big transmitter flat (2) or a bottom or back of resonance (2), which often ideal can be made of metal, on which there is integrated an elastic membrane of cavitation -and after reaction (6), and where this membrane (6) ideal has characteristics, which in the same time allow an acoustics going through of ultra sound (1), in the same time with that this membrane (6) continuous can pick up the energy of the pressure (1') from the just made bubbles of cavitation (1"), and after this momentary and according to the reaction can shut away the bubbles of cavitation (1"), with a further bigger speed or velocity and quantity of energy supplied, with they in just now same direction (1) momentary made bubbles of cavitation (1").

2. Transducer of cavitation (2, 3 4 and 6)) with double intergrated effect head (2 as 6) for respectively homogenizaing as ultra sound cleaning according to claim 1, characteristic of, that the thickness (7) of the elastic membrane of cavitation -as reaction (6) combined can be fitted to the frequency of the transmitting compared with the sound speed or velocity in the elastic material of membrane (6), and ideal as an example as  $\frac{3}{4}$  af lenght of the transmitter wave, and so that there can be obtained full transmission, but still in the same time so, that there also momentary can be obtained a reasonable minimal thickness of reaction (7') for the shadow- or pseudo "membrane of trampoline" (6).

3. Transducer of cavitation (2, 3 4 and 6)) with double intergrated effect head (2 as 6) for respectively homogenizaing as ultra sound cleaning according to claim 1 as 2, c h a r a c t e r i s t i c of, to be mounted  
5 as a row of single transducers (2, 3, 2 and 6) there seperate independent of each other are fluent (10) as elastic hang (10), but which still in the same time also are integrated in a common membrane of cavitaion -and reaction (6), but still one apart seperated and related  
10 reaction -as ultra sound bottom (2).

4. Transducer of cavitation (2, 3 4 and 6)) with double intergrated effect head (2 as 6) for respectively homogenizaing as ultra sound cleaning according to claim  
15 1, c h a r a c t e r i s t i c of, that the single transducer (2, 3, 4 and 6) in battery (9) as single arrangement can be hung fluent (10) via an axial as radial movable arrangment of O-ring (11), and where the single transducer (2, 3, 4 and 6) in the same time can  
20 have an effective and one of here independent membrane of cavitation -as after reaction (2 as 6).

5. Transducer of cavitation (2, 3 4 and 6)) with double intergrated effect head (2 as 6) for respectively  
25 homogenizaing as ultra sound cleaning according to claim 1, c h a r a c t e r i s t i c of, that the membrane of reaction- as cavitation (6) can be exchangeable, and that the swing-and reaction mass (2) ideal for the purpose of function in the same time can be changed in  
30 size, hardness, as according to the properties of the material.

6. Transducer of cavitation (2, 3 4 and 6)) with double intergrated effect head (2 as 6) for respectively  
35 homogenizaing as ultra sound cleaning according to claim 1, c h a r a c t e r i s t i c of, that there in a

12

single transducer (2, 3, 4 and 6) can be integrated one or -more transducers (2', 3', 4' and 6' ), but where these (13) each other can be hung fluent hung (10 as 12') and with each there seperate elastic membranes (6 as 6')  
5 as swing mass head of ultra sound (2 as 2'), and where the head -and mother transducer (2, 3, 4 and 6) can be brought to sound transmitting (1), where the fluent (12') sattelite transducer (2', 3', 4'and 6') further also can be brought to sound transmitting (1'), but into a sound  
10 picture independent of the carrying transducer (2, 3, 4 and 6), but still so that the total ultra sound picture (1 + 1') at the transmitting front (6) will be a sum (1 + 1') of the head transducer supplied with the produced cavitation sound of the sattelite transducer (summa 1).

15

Fig.1

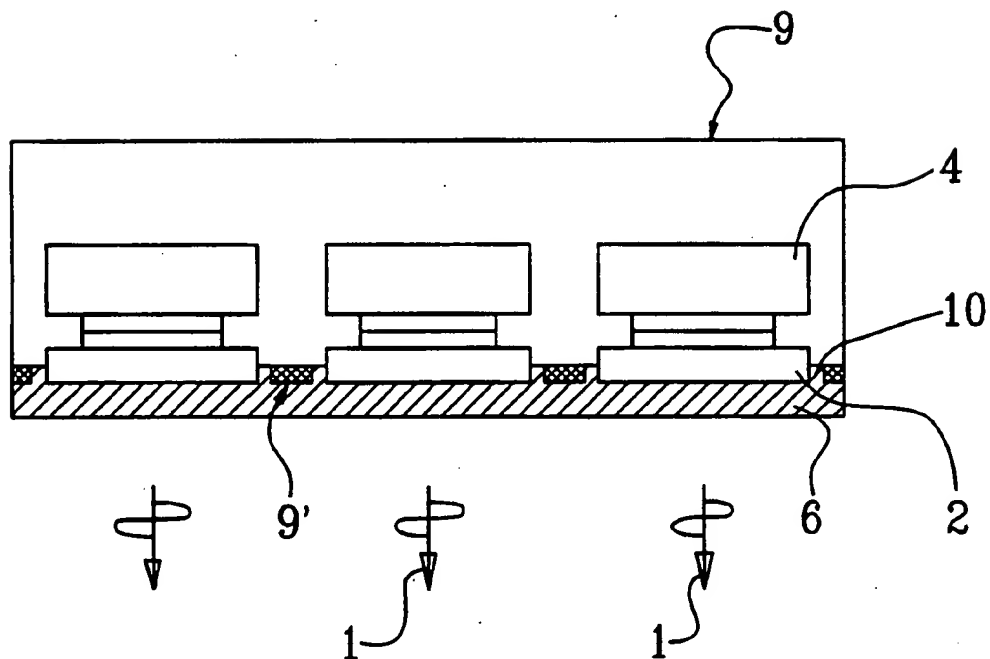
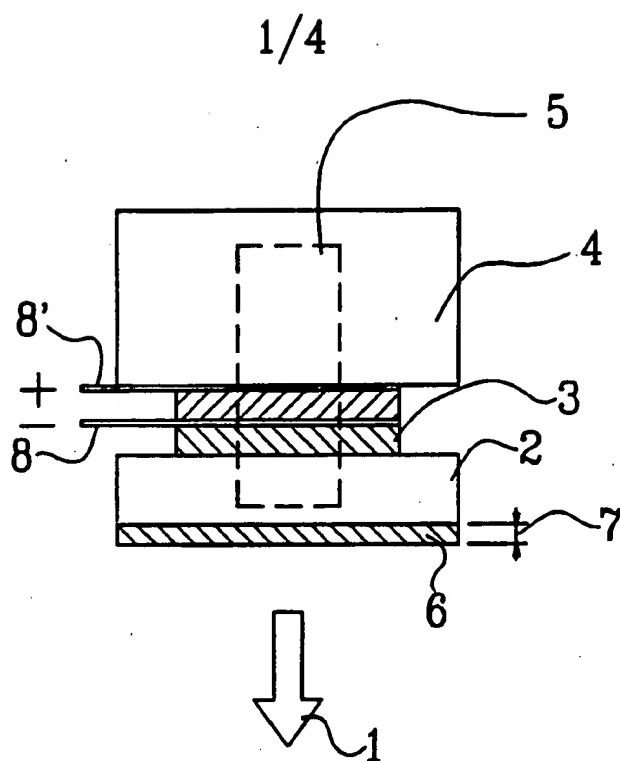


Fig.2

2/4

Fig.3

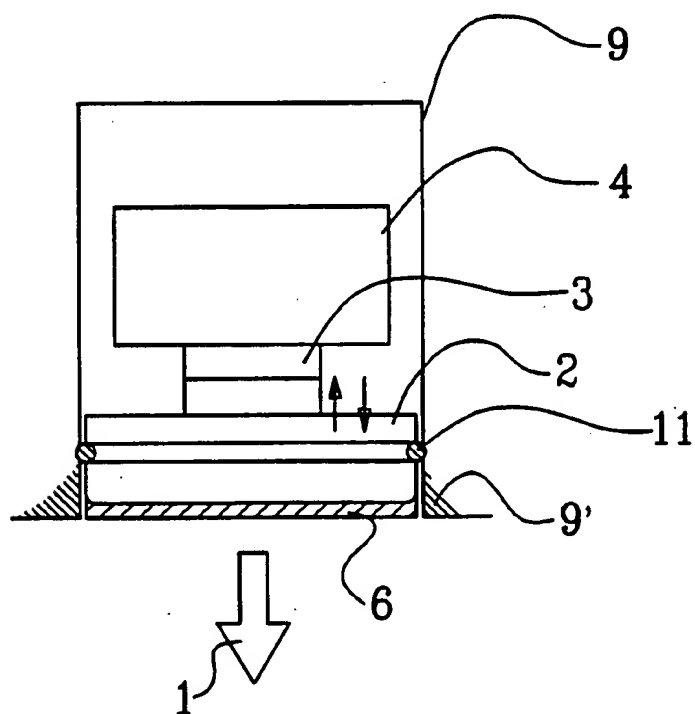
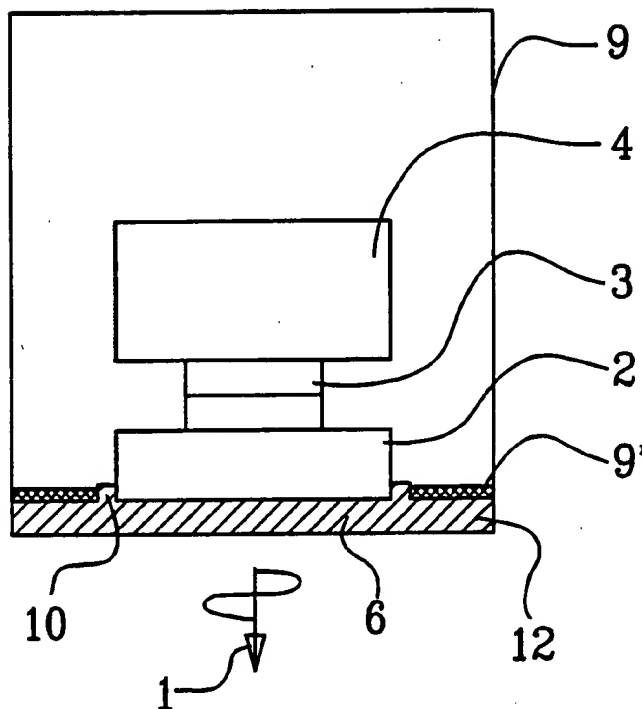


Fig.4



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Fig.5

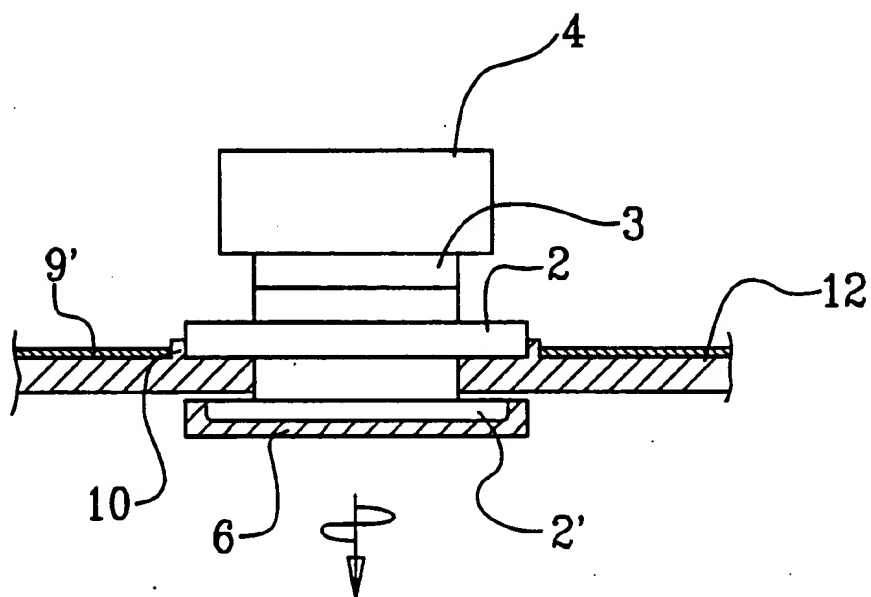
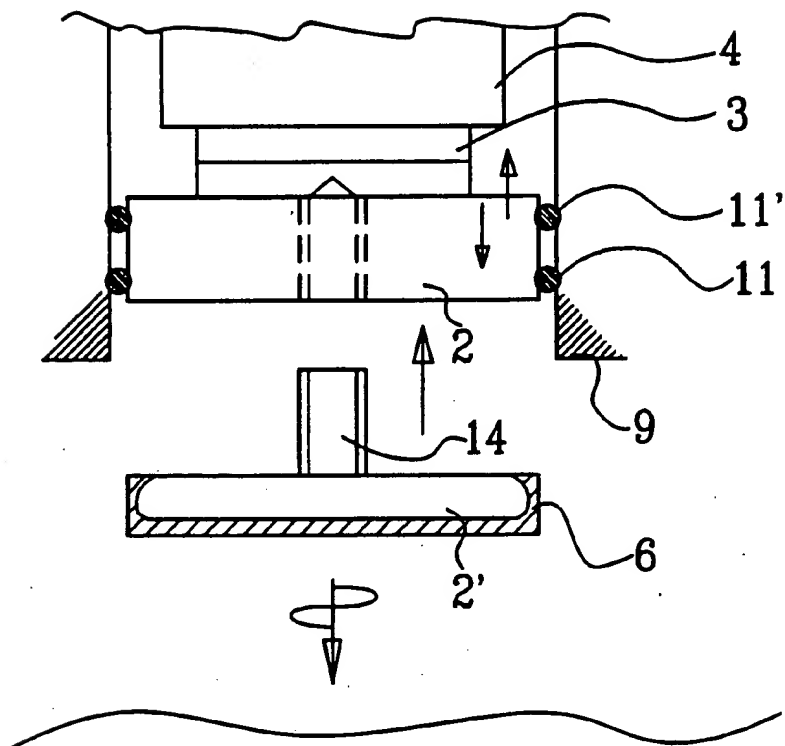


Fig.6

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Fig.7

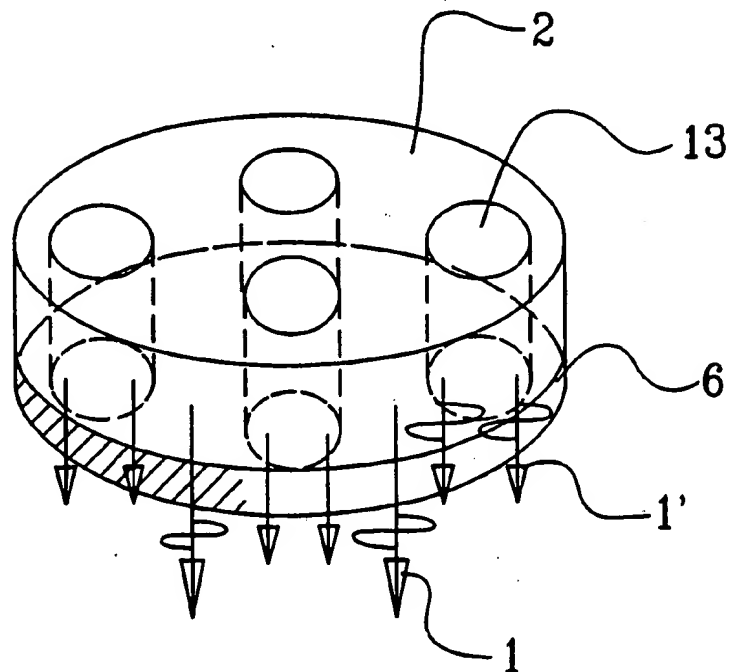
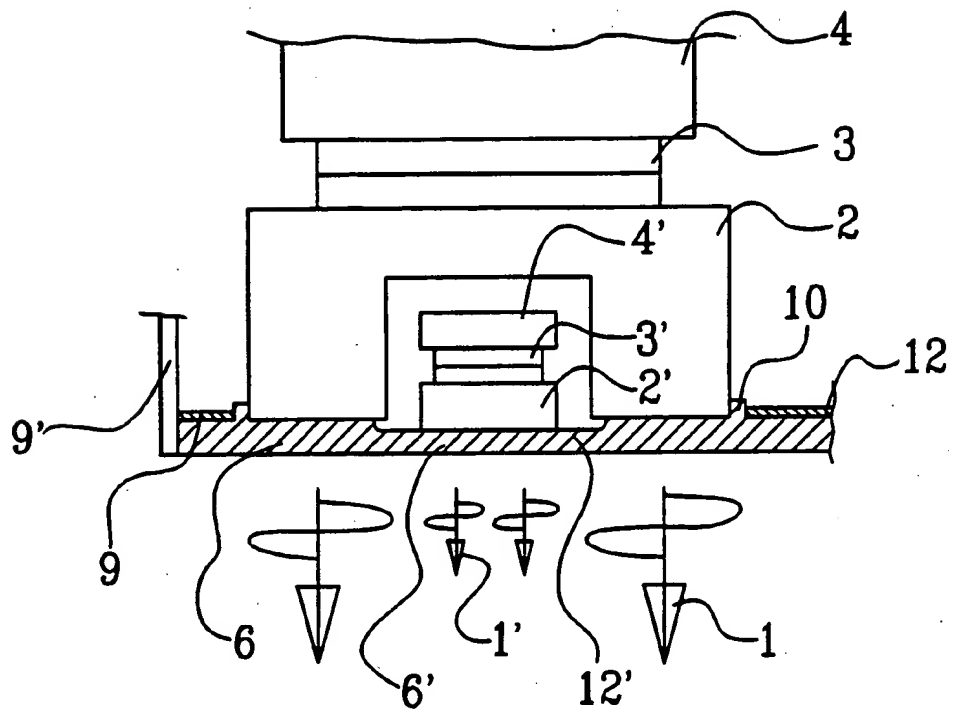


Fig.8

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 93/00263

## A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B01J 19/10, B06B 1/06, B06B 3/00, B01F 11/02  
According to International Patent Classification (IPC) or to both national classification and IPC

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	DE, C1, 4125088 (SIEMENS AG), 11 June 1992 (11.06.92), column 4, line 4 - line 25, figure 1 --	1
A	DE, A1, 3600639 (BOPP & REUTHER GMBH), 23 July 1987 (23.07.87), page 2, line 38 - line 56 --	2
A	DE, A1, 4006718 (MITSUBISHI MINING & CEMENT CO., LTD.), 13 Sept 1990 (13.09.90), figures 1,2 --	3,6

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## INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Information on patent family members

01/10/93

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